

## TECHNICAL REVIEWERS' RATING SUMMARY

### G-017-C

#### Improved Directional Drilling Technology for the Bakken Formation

Submitted by: Laserlith Corporation

Principal Investigator: Wallace Tang

Request for \$500,000 (Phase I); Total Project Costs: \$1,207,000 (Phase I)

Duration: 12 months

Rating Category	Weighting Factor	Technical Reviewer			Average Weighted Score
		17C-03	17C-04 Rating	17C-08	
Objective	9	4	2	3	27.0
Achievability	9	4	3	3	30.0
Methodology	7	2	3	4	21.0
Contribution	7	3	4	3	23.3
Awareness	5	1	4	3	13.3
Background	5	4	4	4	20.0
Project Management	2	3	3	3	6.0
Equipment Purchase	2	2	5	2	6.0
Facilities	2	5	4	3	8.0
Budget	2	5	3	3	7.3
<b>Average Weighted Score</b>		213	164	160	<b>161.9</b>
<b>Maximum Weighted Score</b>		250	250	250	<b>250</b>

### **OVERALL RECOMMENDATION**

#### **FUND**

**FUNDING TO BE CONSIDERED**

**X**

**X**

**X**

**DO NOT FUND**

1. *The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Oil and Gas Research Council goals are: 1 – very unclear; 2 – unclear; 3 – clear; 4 – very clear; or 5 – exceptionally clear.*

Reviewer 17C-03 (Rating:4)

This project is consistent with the following goals and purposes of the North Dakota Industrial Commission/Oil and Gas Research Council:

- Promotes efficiency and creates jobs in North Dakota
- Brings about new opportunities in the oil and gas industry
- Encourages and promotes the use of new technology

Reviewer 17C-04 (Rating: 2)

The reviewer found the description of the objectives and goals in the text of the proposal to be weak in their respect to clarity and consistency in accordance with the North Dakota Industrial Commission/Oil and Gas Research Council goals. The value statement is unclear how better sensing would reduce “trouble time” due to survey inaccuracy, while increasing reserves. Further research, perhaps utilizing energy service companies, would help provide the needed statistics to back up the claims made in the proposal. Item 6.4, aside from the hiring of five engineers/technicians, the proposal creates expectation of the creation of 20-30 jobs in Grand Forks, how these jobs are created, what type of jobs are being created and what is the longevity of such jobs (sales projections) are not noted. The verbiage in Item 6.5 does not offer a convincing link between direction drilling, improved sensing and health, environment and safety in the oil and gas fields of North Dakota. In addition, the presence of evidence is lacking that this effort will promote public awareness in the “benefits and opportunities” of the hydrocarbon extraction industry in North Dakota.

Reviewer 17C-08 (Rating: 3)

Gyro at the bit will decrease the cost of horizontal wells since less time will be spent “sliding” to correct well azimuth. This may bring in new O&G companies & investment to North Dakota.

High potential to create new O&G jobs and revenues—Reduction of well costs may make it more economic to develop potential plays that are currently not economic.

Data from this project is requested to remain confidential. There will probably not be many educational opportunities for industry and the general public.

Will help preserve existing jobs—84 of the 87 rigs are currently drilling horizontal wells.

Could provide baseline information leading to other projects, although only the subject companies would benefit since information is to remain confidential.

2. *With the approach suggested and time and budget available, the objectives are: 1 – not achievable; 2 – possibly achievable; 3 – likely achievable; 4 – most likely achievable; or 5 – certainly achievable.*

Reviewer 17C-03 (Rating: 4)

The team seems to have experience in designing and developing MEMS for high-g environment used with accelerometer and MEMS used in temperature cycling environment. There is adequate experience with respect to IC integration, switching technology and sensors. However, the design and manufacturing of the IC to withstand high downhole temperatures along with packaging of this technology with a miniature gyroscope remains to be the principle challenge of this project!

Reviewer 17C-04 (Rating: 3)

Despite past experience in design of such mechanisms and assurances of a superior fabrication process (page 6), comments on page 7 indicate that due to time and budgetary constraints the circuit will not be fabricated in the first year. The reviewer sees this verbiage as a contradiction. An ongoing risk is that funding is cut for the MEMS foundry in Grand Forks considering current macroeconomic factors that could cause the government to not honor their funding responsibilities.

Reviewer 17C-08 (Rating: 3)

This project is designed for completion in two phases. The goal of Phase I is to develop the micromechanical sensing element, select the specialized high temperature semiconductor, and design the sensor circuit. The sensing element (gyroscope) will be based upon an existing design developed for the Dept of Defense, therefore, reviewer questions the need to spend 6 months on this portion of the project. The goal of Phase II is to prepare the complete sensor for down-hole testing. Reviewer questions why this research is being done in two phases, nevertheless, the timetable is likely achievable.

3. *The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average.*

Reviewer 17C-03 (Rating: 2)

The idea is intriguing and original to have a downhole MEMS gyroscope developed, however, no detailed methodology was provided for developing a high temperature MEMS gyroscope! The technology is supposed to be based on existing high-g gyroscopes and other sensors used in variable temperature environment currently in use for defense purposes.

Very little detail was provided with respect to separating the electronic circuit from the micromechanical sensing element. No data was presented for high temperature exposure of circuitry fabricated in the high temperature microchip foundry. No exposure data was presented for the robust micromechanical sensing element to high temperatures.

Reviewer 17C-04 (Rating: 3)

The methodology is logical but not entirely illuminating.

Reviewer 17C-08 (Rating: 4)

Very few improvements have been made on sensing element in the past decade, mainly since magnetic sensors are used and affected by elements such as bit, drill string, angle to magnetic north, magnetic storms, etc. A gyroscope is not affected by such forces, therefore, development of a sensor that can be attached near the bit will provide many new advances in the guidance of horizontal wells in the future.

4. *The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Oil and Gas Research Council goals will likely be: 1 – extremely small; 2 – small; 3 – significant; 4 – very significant; or 5 – extremely significant.*

Reviewer 17C-03 (Rating: 3)

This project is in line with the following goals and objectives of the North Dakota Industrial Commission/Oil and Gas Research Council:

- Positively affecting ultimate recovery from North Dakota's existing oil and gas pools.

- Identify oil and gas exploration and production technologies presently not used in North Dakota.

Reviewer 17C-04 (Rating: 4)

Better sensing as a result of a gyro that offers tactical or inertial grade performance would offer the potential for better well placement and the potential for increased EUR for all directional wells (not just the Bakken). The ability to create longer and numerous well paths with a lower risk envelope would allow for more pad drilling, reducing the environmental impact of drilling, while reducing facilities costs and reducing waste. The upside to develop additional products outside of drilling is also quite interesting.

Reviewer 17C-08 (Rating: 3)

The scientific and technical contribution will be significant, although since the project is to remain confidential, it will mainly only benefit the parties participating in the project. It will create some new jobs at the University of North Dakota and will help preserve existing jobs since such technology will help lower the cost of drilling horizontal wells. The project claims this improved drilling technology can increase the amount of oil that can be extracted economically from the Bakken Formation, although the work probably will not have a significant impact on ultimate recoveries since effective hydraulic stimulation techniques during completion currently holds the key to effective Bakken recoverable reserves.

5. *The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research related to the proposal is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.*

Reviewer 17C-03 (Rating: 1)

No literature review was provided.

Only one reference was cited (Thomas Lee) – Page 6.

Previous work by the PI and co-PIs were mentioned.

Reviewer 17C-04 (Rating: 4)

The reviewer is not sure how technology management translates to expertise in technology design but the proposal is robust enough to suggest sufficient awareness of the subject matter by the principal investigator.

Reviewer 17C-08 (Rating: 3)

The principal investigator did not address any other research activity or publications, although reviewer assumes he has adequate knowledge of such activity or literature.

6. *The background of the investigator(s) as related to the proposed work is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.*

Reviewer 17C-03 (Rating: 4)

The PI and co-PI have adequate experience to develop this technology.

Reviewer 17C-04 (Rating: 4)

The additional investigators have very good credentials related to the proposed work. One criticism would be the reader is not availed to the type of engineers or technicians that would be hired for such an effort as they would be seen as future investigators.

Reviewer 17C-08 (Rating: 4)

Much of the previous MEMS research has been conducted by the participants in this project. Many references are made to research conducted for the Dept of Defense, although specific documentation was not detailed. The reviewer believes the principal investigator has extensive knowledge in MEMS research and gyroscopic surveying.

7. *The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.*

Reviewer 17C-03 (Rating: 3)

The various tasks and responsibilities are assigned according to expertise. The overlap in technical expertise needed to transition product development and testing from one site to another is not identified. Close communication and coordination of activities would be needed between various sites for a successful outcome of a project such as this. This was not addressed in the proposal. A rough two-year budget allocation was provided.

Reviewer 17C-04 (Rating: 3)

While brief, the project plan does not offer details in regards to the communication plans between the investigator and subcontractors. There is little data to indicate the type of indirect costs that are being “contributed” to this project by the various parties.

Reviewer 17C-08 (Rating: 3)

The proposal has a realistic timeframe and financial outline although reviewer questions the need for 6 months of design work on the mechanical sensing element since it will be based upon an existing design already developed for the Dept of Defense.

8. *The proposed purchase of equipment is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)*

Reviewer 17C-03 (Rating: 2)

Material and equipment budget for each year is \$200K. No justification or detail is provided for equipment purchases in the proposal.

Reviewer 17C-04 (Rating: 5)

While comments in the proposal are vague in their description and intent to purchase items, the proposed items such as electroplating systems would be justified.

Reviewer 17C-08 (Rating: 2)

\$250,000 is included as matching funds with which MicroAssembly will customize a fab run. No documentation is included to identify any specific equipment.

9. *The facilities and equipment available and to be purchased for the proposed research are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.*

Reviewer 17C-03 (Rating: 5)

The PI and co-PI have more than adequate facilities to conduct this research. This was concluded based on information provided about previous experience along with the support letters from various agencies.

Reviewer 17C-04 (Rating: 4)

The use of products such as L edit should provide sufficient support for MEMS design, while applications like ANSYS should allow for excellent structural and thermal analysis. The access to the new MEMS foundry also makes the project attractive.

Reviewer 17C-08 (Rating: 3)

The proposal did not list the equipment in detail, but did indicate Ideal Aerosmith has a facility located in the COELSAT REAC building located next to the UND campus.

*10. The proposed budget “value”<sup>1</sup> relative to the outlined work and the financial commitment from other sources is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. (See below)*

Reviewer 17C-03 (Rating: 5)

The outcome of the proposed work will not only have significant value with respect to dog-leg and directional drilling activities but will also impact future exploration and production activities. This technology could assist in collecting accurate and valuable data from various formation and reservoir location(s). It also would assist in optimizing simulation activities with respect to secondary and tertiary oil and gas recovery!

1<sup>st</sup> year – Phase 1

Direct matching = \$250,000 – 21%

Indirect matching = \$457,000 – 38%

2<sup>nd</sup> year – Phase II

Direct matching = \$250,000 – 14%

Indirect matching = \$838,500 – 47%

Phase 1 has a total matching of 59% and phase II has a total matching of 61%.

Reviewer 17C-04 (Rating: 3)

While costs seem reasonable, as noted earlier there is little data to indicate the type of indirect costs that are being “contributed” to this project by the various parties. Assigning what would essentially be “overhead” costs, as a contribution to the project, seems to indicate to the reviewer a lack of capital by the project sponsors. Additionally the reviewer is curious why companies, such as Halliburton, Schlumberger and Baker Hughes, while being cited as interested in the technology, have not acted as financial sponsors even though they will directly benefit from the development of the technology?

Reviewer 17C-08 (Rating: 3)

The grant request of \$500,000 is 41% of the total cost of the \$1.207 million project. Laserlith Corporation’s \$357,000 matching contribution is for “indirect” costs and Ideal Aerosmith’s \$100,000 matching contribution is also for “indirect” costs although such “indirect” costs were not identified. Reviewer questions if these indirect costs are justified.

*Section C. Overall Comments and Recommendations:*

*Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.*

Reviewer 17C-03 (FUNDING MAY BE CONSIDERED)

The proposal leaves some major gaps in technical discussions about developing a high temperature microchip that will withstand extreme temperatures. It also does not specify any

target temperatures as the temperature gradient may vary even at various depth for the Bakken formation. No target temperatures were mentioned for the research.

No detailed methodology was provided for developing a high temperature MEMS gyroscope. It is supposed to be based on existing high-g gyroscopes and other sensors used in variable temperature currently in use for defense purposes. Very little detail was provided with respect to separating the electronic circuit from the micromechanical sensing element. No data was presented for high temperature exposure of circuitry fabricated in the high temperature microchip foundry. No exposure data was presented for the robust micromechanical sensing element to high temperatures. Literature review was not presented or performed.

The idea is intriguing and original to have a downhole MEMS gyroscope developed. Such gyroscope could have significant value with respect to dog-leg and directional drilling activities but will also impact future exploration and production activities. This technology could assist in collecting accurate and valuable location and depth data from various formation and reservoir location(s). It also would assist in optimizing simulation activities with respect to secondary and tertiary oil and gas recovery.

The proposal presented bits of information about MEMS electronic integration technology and hinted on proprietary technology for low-parasitic micromechanical sensor with specialized high temperature circuitry. What would be needed is a final packaging for all the technology that could withstand high pressures and temperatures.

However, given the history of expertise of the parties involved and MEMS and sensor technology currently available or viable, the funding requested outweighs the risks involved. My recommendation is to consider funding.

**Reviewer 17C-04 (FUNDING MAY BE CONSIDERED)**

In general, the project does offer the possibility of creating permanent jobs in North Dakota while developing technology that will assist in increasing the accuracy of wellbore placement in hydrocarbon bearing reservoirs. Success of this effort should be high as the technology has been created for another application (defense) and can potentially be expanded for use in the harsh conditions of drilling. The downside is the lack of specific information on the level of accuracy that will be strived for (the grade of gyroscope), and what measures will be used to minimize drift.

The reviewer understands timing is critical and proposes the attraction of necessary resources may push back the time line for development of this technology. However, the principal investigator and primary investigators are experienced in technology development which should mitigate human resource issues.

Costs to develop the technology seem reasonable. From a financial standpoint, the reviewer is critical of the proposal's suggestion that indirect (or overhead) costs be used as a form of financial contribution ("matching funds") from both Laserlith and Ideal Aerosmith. There is little description of these indirect costs, how they would be billed (assigned) to the project and then tracked. In turn, the contribution of a fab run to be seen as a contribution (Microassembly) would need to be validated by a further description of the costs of set up, etc.

I would recommend that the State of North Dakota partially fund this project dependent upon the proposal's sponsors ability to garner matching funds from the service companies they will seek as future customers of this technology, or other funding is garnered from the proposal's sponsors that does not include indirect costs. In addition, it is the opinion of the reviewer that the State of

North Dakota should share in the patent of the new product and the revenue generated from its sales.

**Reviewer 17C-08 (FUNDING MAY BE CONSIDERED)**

Reviewer would have liked additional documentation on the cost of MicroAssembly's fab run and the matching fund contributions (indirect costs) claimed by Laserlith Corporation and Ideal Aerosmith.

The proposal indicates Schlumberger, Halliburton, and Baker Hughes all have confirmed strong interest for this project although no monetary contribution was documented.

Reviewer questions the confidentiality request and whether a time limit should be imposed since NDOGRC funds are being requested to partially fund this project.

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<sup>1</sup> *"Value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar.*

*Financial commitment from other sources* – *A minimum of 50% of the total project must come from other sources to meet the program guidelines. Support less than 50% from Industrial Commission sources should be evaluated as favorable to the application.*